(B5)

(12) UK Patent Application (19) GB (11) 2 158 322 A

(43) Application published 6 Nov 1985

(21) Application No 8507878

(22) Date of filing 26 Mar 1985

(30) Priority data
(31) 8410597 (32) 25 Apr 1984 (33) GB

(51) INT CL[4]
H04N 5/262

(52) Domestic classification
H4F D12M D12X D1B9 D1D1 D30B D30K D30T1 D30T2 D30T3 D30X D57 D58 GX

(56) Documents cited
GB A 2044580 GB 1594341

(58) Field of search
H4F

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(54) **Improvements in or relating to video signal processing systems**

(57) In a video signal processing system producing the same output image as the input image but with a size or shape change applied to it, the incoming video signals are written into a frame store 10, 16 in sequence but read out in an order determined by the output image required. When compression in the image occurs the luminance signals are filtered 7, 8 prior to writing in the store 10. A computer 21 determining the sequence of reading from the frame stores controls filters 7, 8 *via* coefficient generator 26 to reduce the resolution of the luminance signals written into store 10 if necessary.

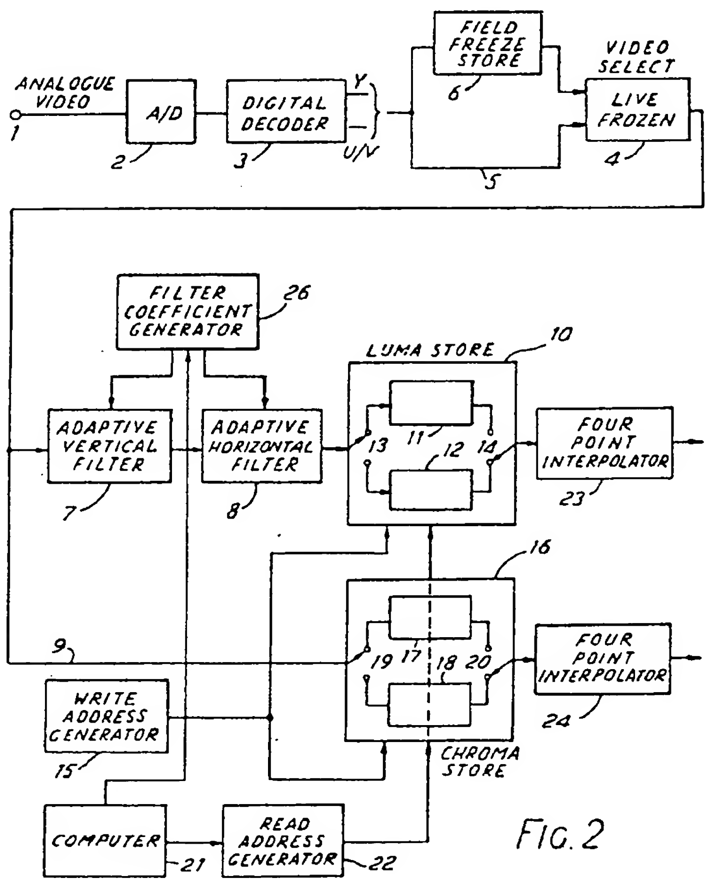

FIG. 2

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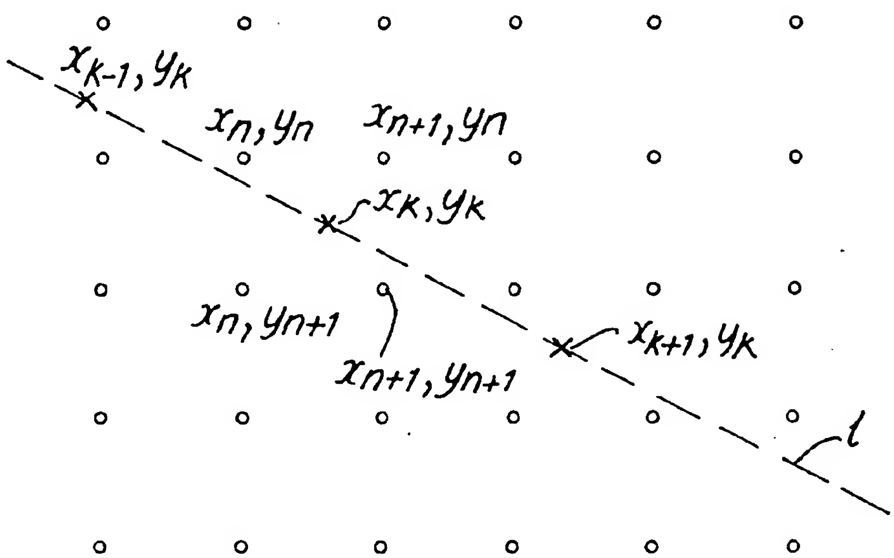

FIG.1

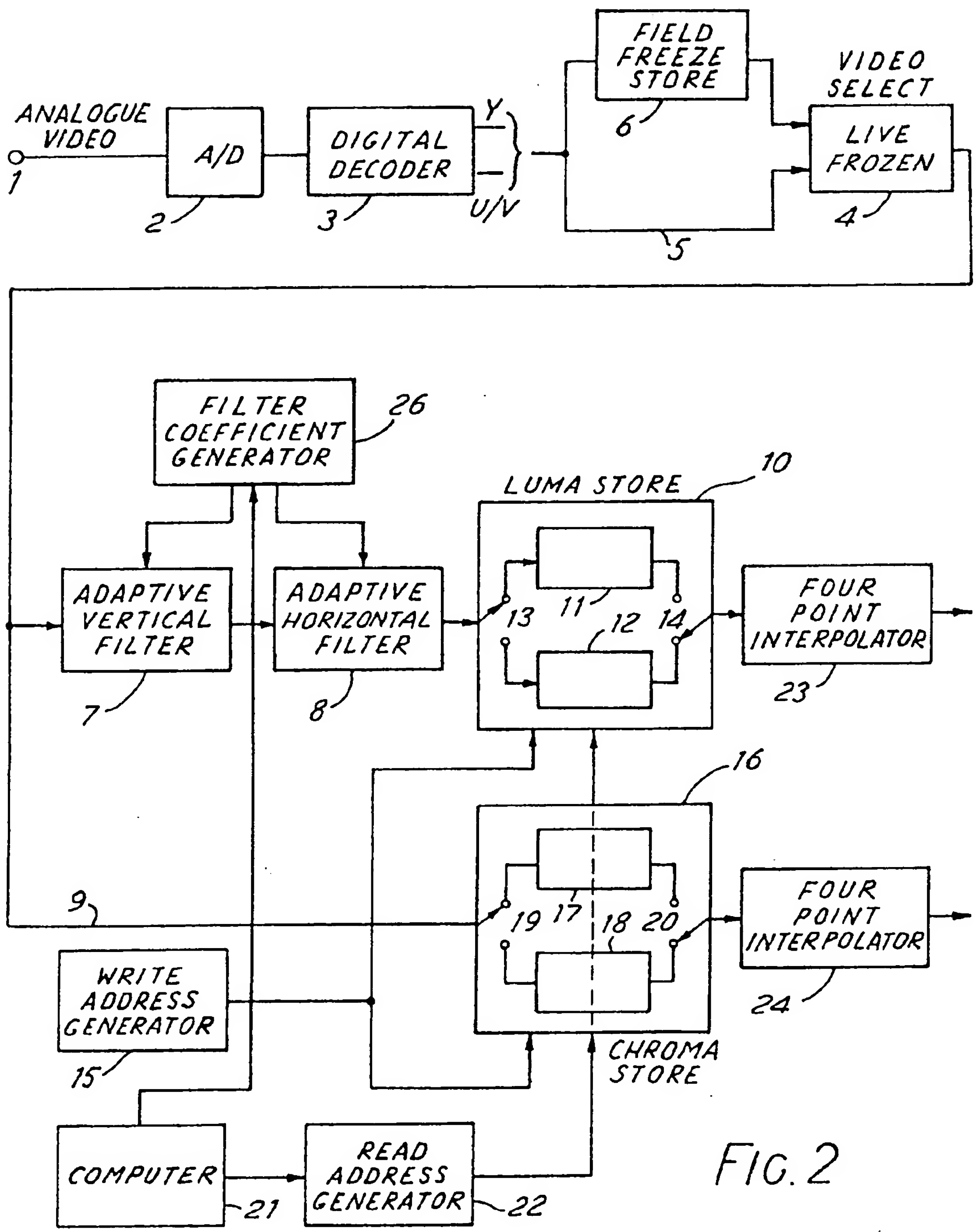
ANALOGUE VIDEO
1
A/D
2
DIGITAL DECODER
3
Y
U/V
FIELD FREEZE STORE
6
5
VIDEO SELECT
LIVE
FROZEN
4
FILTER COEFFICIENT GENERATOR
26
ADAPTIVE VERTICAL FILTER
7
ADAPTIVE HORIZONTAL FILTER
8
LUMA STORE
10
11
12
13
14
FOUR POINT INTERPOLATOR
23
16
17
18
19
20
9
FOUR POINT INTERPOLATOR
24
CHROMA STORE
WRITE ADDRESS GENERATOR
15
COMPUTER
21
READ ADDRESS GENERATOR
22

FIG. 2

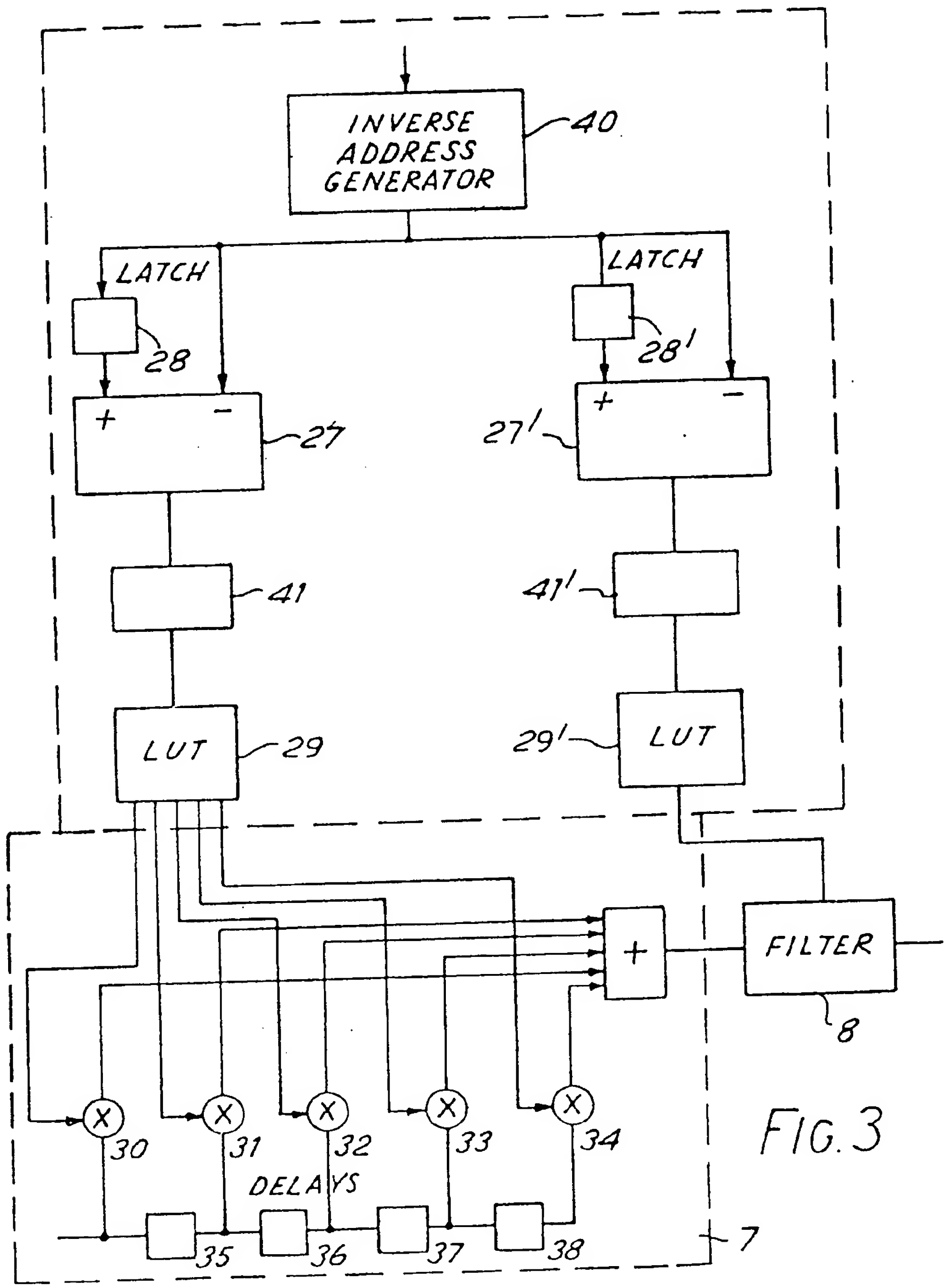
INVERSE ADDRESS GENERATOR
40
LATCH
LATCH
28
28'
+
−
27
27'
41
41'
LUT
29
LUT
29'
+
FILTER
8
30
31
32
33
34
DELAYS
35
36
37
38
7

FIG. 3

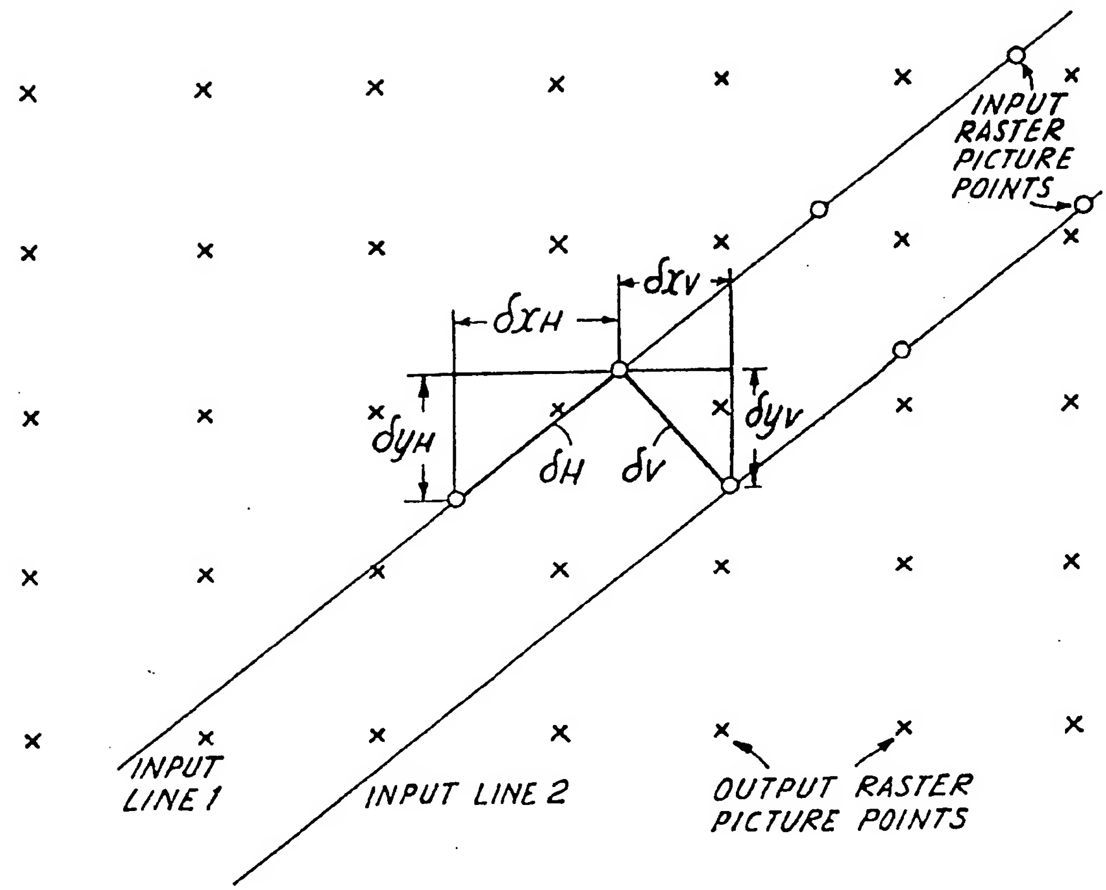
δxH
δxV
δyH
δyV
δH
δV
INPUT RASTER PICTURE POINTS
INPUT LINE 1
INPUT LINE 2
OUTPUT RASTER PICTURE POINTS

FIG. 4

SPECIFICATION

Improvements in or relating to video signal processing systems

Background to the Invention

This invention relates to video signal processing systems, especially systems for manipulating television signals in digital form to produce effects such as changes in magnification, shape, orientation or position of the image or part thereof.

In one form of such a system, as described in our co-pending U.K. Patent Application No. 8108467, incoming video signals, after conversion to digital form, are written in a frame store in input raster format, so that successive pixels of the digitised signals are assigned to successive storage locations in the store. They are then read from the storage locations in a different sequency, and this sequence is predetermined to produce the desired effect when the signals are reproduced. The operation is illustrated in Fig. 1 of the accompanying drawings in which the small circles represent a patch of storage locations in the frame store in which are stored, during the writing operation, the digital signals representing a group of successive pixels in each of a group of successive lines in a field of the input raster. Four adjacent storage locations are denoted as having addresses x_n, y_n; x_{n+1}, y_n; x_n, y_{n+1} and x_{n+1}, y_{n+1} respectively, x and y being the along-line and across-line co-ordinates relative to the input raster. In the same figure the small crosses represent the addresses from which a few successive pixels should be read in line *1* of the output signals. Such addresses are selected according to the effect which is desired, and in general the addresses of the pixels in the output signal raster will not coincide with the storage locations in the frame store. Therefore the pixels used to build up the output signals are synthesised by interpolating among the pixels written in the storage locations adjacent the addresses of the output pixels. For example, the output pixel having the address denoted as x_x, y_k in Fig. 1 would be synthesised by interpolating among the input pixel written at the addresses x_n, y_n; x_{n+1}, y_n; x_n, y_{n+1} and $x_{n+1, yn+1}$. Each address such as k_k, y_k is derived by transforming the address co-ordinates of the pixel in the output signal raster (say x_k, y_k) into the coordinates related to the input signal raster. Consideration of Fig. 1 will indicate that (assuming the line *1* is representative of the output signal raster) the output signals, when read from the frame store will represent the same image as the input signals, but the image would be compressed and rotated compared with the image represented by the input signals.

A system such as described in the preceding paragraph is a flexible means of achieving production effects. A disadvantage is however encountered occasionally when image compression is effected. Reference to Fig. 1 will show that as the compression factor increases to and beyond 2 (magnification equal to 1/2) the output signals will be unable to resolve detail of short wavelength, of the order to 2 pixel dimensions, in the output raster, and the interpolation used to synthesise the pixels to build up the output signals tends to produce noticeable disturbances in the image.

Object of the Invention

The object of the present invention is to provide an improved video signal processing system in which this disadvantage is reduced.

Summary of the Invention

According to the present invention there is provided a video signal processing system comprising;

storage means, means for writing pixels of the input video signals in respective addresses of said storage means and,

means for reading pixels from said storage means in a different sequence to produce output video signals representing the same image as the input video signals but with at least a change in magnification, and wherein means are provided responsive to compression of the image represented by the output video signals relative to that represented by the input video signals to filter the video signals prior to reading from said storage means to a degree dependent upon the compression. Preferably the filtering is carried out prior to writing the input video signals in said storage means. Preferably said filter means is able to respond to changes in compression occurring as between one part and another of the image represented by the video signals.

Brief Description of the Drawings

In order that the present invention may be more clearly understood and readily carried into effect, the same will be more fully described with reference to the accompanying drawings in which:–

Figure 1 has already been referred to;

Figure 2 illustrates, mainly in block form, on example of a system according to the present invention;

Figure 3 illustrates, in more detail, the adaptive filter means incorporated in the system illustrated in Fig. 2;

Figure 4 is an explanatory diagram.

Detailed Description of the Invention

Referring to the drawings, reference 1 Fig. 2 denotes the input terminal of the system to which is applied, in operation, input video signals in analogue form, representing an image which it is desired to manipulate in order to produce effects wμsuch as changes in magnification, shape, orientation or position, or

combinations thereof. The signals may be derived from a camera, a video tape recorder or other source of video signals. The signals may, in general, relate to a moving image, the system which is about to be described being capable of operating in real time. The video signals from the terminal 1 are applied to an analogue-to-digital converter 2 which converts the signals to a sequence of digital samples. The output signals from the converter 2 are fed to a digital decoder 3 which derives from the digital samples two data streams each of 13.5 MHz. One stream comprises the luminance (Y) pixels of the video signals and the other comprises the two colour differences (U and V) pixels each of 6.75 MHz, time multiplexed into one stream. The Y pixels occur in a sequence of lines and fields and the timing of the pixels in relation to the television frame periods indicates the x and y co-ordinates in the image. The U and V pixels are co-sited with every other Y pixel. The digital data streams from the decoder 3 are passed either to a video signal selector 4 via the highway 5, or to a field freeze store 6 in which a field of video signals Y, U and V can be accumulated during one field period. The selector 4 can be controlled by the operator either to transmit directly the digital data streams on the highway 5, or to block these streams, and to transmit repeatedly the last field of data signals accumulated in the field store 6, the input in the field store being blocked when this is taking place. This gives the operator the choice of transmitting either a moving or a still picture. The selector 4 may also have a third function, namely to select streams of video signals representing a border for transmission to following stages, but this function is well known and need not be further described; for simplicity only Y and U/V video streams will be considered in the following description.

The Y pixels from the selector 4 are passed in sequence to two adaptive filters 7 and 8. The filter 7 is arranged to produce a variable degree of so called vertical filtering and the filter 8 produces a variable degree of horizontal filtering. The filtering has the effect of reducing the resolution of the Y signals as will be described subsequently. The U and V pixels are each already of reduced resolution compared with the Y pixels, and so are by passed round the filters via a path 9.

The luminance pixels from the filters, 7 and 8 are fed to a luminance frame store 10 comprising two field stores 11 and 12 by way of a switch 13. The switch is controlled so that luminance pixels are written in the field stores 11 and 12 alternatively during successive field periods. The locations in the field stores at which the luminance pixels are written is controlled by a write address generator 15, which addresses the storage locations in the sequence of the pixels in the input raster, such as represented in Fig. 1. The chrominance pixels U and V from the selector 4 are similarly fed to a chrominance frame store 16 comprising two field stores 17 and 18, by way of switch 19. The write address generator 15 serves the store 16 as well as the store 10, and controls the locations on the field stores 17 and 18 at which the U and V pixels are written. Signals are read from the frame stores 10 and 16 via respective switches 14 and 20, which are operated in anti-phase to the switches 13 and 19 so that reading takes place during successive field periods from that one of the two field stores 12, 13 or 17, 18 in which writing occurred during the proceeding field period. The switches 13, 19 and 14, 20 are controlled in known manner by the sequencer of the system, which is not shown.

The references 21 and 22 denote a computer and a read address generator for the stores 10 and 16. The computer is arranged to generate the transforms for calculating the addresses in the stores 10 and 16 from which should be derived the pixels in the output signal raster. The transforms are updated in the computer at field rate and applied to read address generator 22 during respective field blanking intervals. The read address generator 22 is in turn arranged to generate the addresses for successive pixels in each field in response to the transforms, in the co-ordinate system of the input raster, the addresses of successive pixels in the output raster. For example, during one line of the output raster of the system, the address generator 22 will generate, in succcession, and at pixel rate, addresses such as represented by x_{k-1}, y_{k-1}; x_k, y_k and x_{k+1}, y_{k+1} in Fig. 1. As indicated these addresses will occur in the same line of the output signal raster. For each address so generated, the read address generator 22 applies read signals to four storage locations in field store 11 or 12 closest to the generated address. For example, if the read address generator generates the address x_k, y_k as shown in Fig. 1, the read address generator will apply read signals to the four addresses x_n, y_n; x_{n+1}, y_n; x_n, y_{n+1} and x_{n+1}, y_{n+1}.

The generator 22 operates in a similar way in relation to the field stores 17 and 18, except that in this case the read signals are applied to the four nearest storage locations holding U or V pixels, as the situation requires. The four pixels read from the store 10 at any one time, are fed to a four point Y-interpolator 23, and the four pixels read from the store 16 are applied to a four point U- or V- interpolator 24. Each interpolator combines the four pixels read from the stores 10 or 16 in proportions determined by interpolation co-efficients generated by the address generator 22. The interpolation co-efficients are such as to produce for each address, such as x_k, y_k a pixel approximating to the value of the luminance or the respective chrominance compo-

nent of the image at the respective point. The computer 21, the address generator 22 and the four point interpolators 23 and 24 may be of any suitable construction, such for example, as that used in the digital production effects equipment DPE 5000 manufactured by us, or as described in our Patent Application No. 8108467, the subject matter of which is herein incorporated by reference. The output signal streams may be re-coded to conform to one or other of the standard colour television waveforms, reconverted to analogue form, and then transmitted, recorded or processed in desired ways.

The effect on the image produced by the system will depend on the particular co-ordinate transformation carried out by the computer 21 in conjunction with the address generator 22. The image change may be initiated by the operator with the aid of a joystick or other control means causing the computer to generate the required matrix transforms. Alternatively the output addresses for a particular effect may be predetermined in the form of an address map, or a sequence of such maps, and stored for use when required. As aforesaid, and as illustrated in Fig. 1, one of the effects which can be produced is image compression, which may be produced on its own, or in association with other effects, such as rotation or translation. Moreover, certain effects may result in only part of the image being compresses, or in the compression being variable with position on the image. This is particularly so when the effect of perspective is taken into account in the manipulation of the image.

To reduce the disadvantage referred to above, which may arise when compression occurs, the computer 21 is arranged not only to generate the transforms required for the address generator 22, but also to generate the inverse transforms. These are applied to a filter co-efficient generator 26 which is arranged to generate the address for the pixels of the input video signal transformed to the co-ordinate system related to the output raster. For example, in the representative situation illustrated in Fig. 1, the computer 21 will generate the address of the pixel at x_n, y_n in terms of the output co-ordinate system. The address, say x_r, y_r will be close to x_k, y_k above referred to. Such addresses are generated for each pixel of the input video signals, in the sequence determined by the input raster. These transformed input addresses are used in filter co-efficient generator 26, to control the degree of filtering carried out by the adaptive filters 7 and 8.

Referring not to Fig. 3, the inverse address generator in the filter co-efficient generator 26 is represented at 40. The filter co-efficient generator also comprises two substracting circuits 27 and 27′ for the transformed components of each input pixel address as viewed on the output raster.

The respective x and y components of successive addresses of vertically adjacent input pixels, as viewed on the output raster are applied to a subtracting circuit 27 both directly and via a latch 28 which produces a delay of one line period. The subtracting circuit subtracts the respective components of the two addresses applied to 27 at any one pixel period to produce the differences δx_v and δy_v. Similarly the respective components of successive addresses of horizontally adjacent input pixels, as viewed on the output raster are applied to the subtracting circuit 27′, both directly and via a latch 28′ which produces a delay of one pixel period. The subtracting circuit subtracts the respective components of the two addresses applied to 27′ and any one pixel period to produce the differences δx_H and δy_H. The two differences δx_v and δy_v are applied to an arithmetic circuit 41 which calculates a vertical address difference represented by:

$$\delta V = (\delta x_v)^2 + (\delta y_v)^2$$

Similarly the two differences δx_H and δy_H are applied to a second arithmetic circuit 41′ which calculates a horizontal address difference represented by:

$$\delta H = (\delta x_H)^2 + (\delta y_H)^2$$

The differences δv and δH which are represented in Fig. 4 are applied to two look up tables 29 and 29′. the look up table 29 is arranged to deliver filter co-efficients to the vertical filter 7. This filter, as shown in Fig. 3, comprises a sequence of digital multipliers 30 to 34 to which the luminance signal stream is applied via a sequence of delay latches 35 to 38, each imparting a one line delay to the luminance pixels. The co-efficients delivered to the filter from the look up table 29 are applied as multipliers to the multiplying circuits 30 to 34 and the products of the multiplications (occurring at any one time) are added together in an adding circuit 39 to form the output of the filter. It will be understood that by a suitable choice of the filter co-efficients different filter characteristics can be simulated to selectively reduce the vertical resolution of the input pixels. If at a given time the effect produced by the system does not include compression of the image, or if the compression factor is less than some chosen threshold the output signal from the differencing circuit 27 exceeds a given threshold and the look up table 29 is so arranged that, in this situation, the filter co-efficient applied to the multiplying circuit 32 is unity and the co-efficients applied to the other multiplying circuits are zero. As a result the luminance pixels are passed through the filter without reduction in resolution. If, on the other hand, the difference signal is below

the compression threshold value, the filter co-efficients read from the look up table are selected to conform to a filter characteristic having a maximum in the middle position at the multiplier 32, and being non-zero to either side, so that the resolution of the luminance pixels is reduced. This filter characteristic is moreover adaptive, that is to say responsive with value of the difference signal, in such a way as to reduce the resolution progressively (dependent on the choice of filter co-efficients selected from the look up table 29) as the compression of the image represented by the output signals increases, so as to substantially avoid the undesirable disturbance of the compressed image.

In a similar manner, the look up table 29', stores sets of pre-determined filter co-efficients for application to the horizontal filter 8 in response to the signal SH. This filter is of a similar construction to the vertical filter 7 except that, in this case, the delays equivalent to 35 to 38 are of one pixel period only. The filter 8 is adaptive in a similar manner to the filter 7, and it adapts the horizontal resolution of the luminance pixels to compression produced subsequently in the system. In the case of the filter 8, the input addresses to the co-efficient generator are aligned with the central outputs of the vertical filter. However, a delay of several pixels is required to correspond to the delay to the central input of the horizontal filter.

It will be understood that the construction illustrated for the filters 7 and 8 is merely one practical form of digital filter and other suitable filters may be employed. The number of multipliers such as 30 to 34 may also be varied depending on the maximum degree of filtering which may be required.

Numerous modifications may be made in the system described. For example, the horizontal and vertical differences SH and Sv can be approximated by directly summing Sx_H and Sy_H in the one case and Sx_v and Sy_v in the other. It may not be necessary to transform the address of every luminance pixel in the input video signals into the co-ordinate system associated with the output raster. It may for example to sufficient to transform only every eighth pixel in every eighth line, appropriate changes being made in the delay of 28 and 28'. The adaptive filters 7 and 8 would be responsive to changes in the compression on a relatively course scale, compared with the arrangement described. A key signal may be transmitted along with the luminance pixels and itself filtered according to the compression of the image. In this case, the output signals from the interpolators 23 and 24 may be passed to respective combining circuits to which are also applied luminance, key and chrominance signals from another system similar to that described. The combiner is arranged to select the luminance and chrominance signals from one or other system depending on the relationship of the key signals at any particular time, and to produce a composite signal from the selected signals.

Furthermore, additional filter stores may be inserted in the system, before the adaptive filters 7 and 8 or after the interpolators 23 and 24.

CLAIMS

1. A video signal processing system comprising;
storage means,
means for writing pixels of the input video signals in respective addresses of said storage means,
means for reading pixels from said storage means in a different sequence to produce output video signals representing the same image as the input video signals but with at least a change in magnification,
means for determining the compression of the image represented by the output video signals relative to that represented by the input video signals,
and filter means responsive to said compression to filter the video signals prior to reading from said storage means.

2. A video signal processing system as claimed in Claim 1 wherein said determining means further comprises;
means responsive to changes in compression occurring as between one point and another of the image represented by the video signals.

3. A video signal processing system as claimed in Claim 1, wherein said filter means includes means to allow a chrominance part of the video signals to pass through without the filter acting on it.

4. A video signal processing system as claimed in Claim 1, further comprising;
means for generating a transform for calculating the addresses in the storage means from which should be derived the pixels in the output signal raster,
means for generating the inverse of said transform,
and means for generating co-efficients to control the degree of filtering carried out by the filter means, said co-efficient generating means operating in response to said inverse transform.

5. A video signal processing system as claimed in Claim 4, wherein said co-efficient generating means includes means for producing a signal representing the horizontal and a signal representing the vertical differences between input pixel addresses transformed by said inverse transforms, said differences being used in the selection of filter co-efficients.

6. A video signal processing system as claimed in Claim 1, wherein means are provided for switching filter co-efficients so that the video signals are not reduced in resolution when passing through the filter,

said means operating said compression is less than a threshold level.

7. A video signal processing system as claimed in Claim 1, wherein means are provided to filter a key signal associated with incoming video signals.

8. A video signal processing system as claimed in Claim 1, wherein said filter means is arranged to act on the video signals prior to writing in the frame store.

9. A video signal processing system substantially as described herein, with reference to the following drawings.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1985, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.